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**A Deep Learning Based Approach for Grading of Diabetic Retinopathy Using Large Fundus Image**

**A PROJECT REPORT**

***Submitted by***

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**ABSTRACT**

Diabetic Retinopathy affects one-third of all diabetic patients and may cause vision impairment. It has four stages of progression, i.e., mild non-proliferative, moderate non-proliferative, severe non-proliferative and proliferative Diabetic Retinopathy. The disease has no noticeable symptoms at early stages and may lead to chronic destruction, thus causing permanent blindness if not detected at an early stage. The proposed research provides deep learning frameworks for autonomous detection of Diabetic Retinopathy at an early stage using fundus images. The first framework consists of cascaded neural networks, spanned in three layers where each layer classifies data into two classes, one is the desired stage and the other output is passed to another classifier until the input image is classified as one of the stages. The second framework takes normalized, HSV and RGB fundus images as input to three Convolutional Neural Networks, and the resultant probabilistic vectors are averaged together to obtain the final output of the input image. Third framework used the Long Short Term Memory Module in CNN to emphasize the network in remembering information over a long time span. Proposed frameworks were tested and compared on the large-scale Kaggle fundus image dataset EYEPAC. The evaluations have shown that the second framework outperformed others and achieved an accuracy of 78.06% and 83.78% without and with augmentation, respectively.

**CHAPTER 1**

**INTRODUCTION**

Diabetic Retinopathy (DR) is a chronic eye disease, commonly found in elderly people (age 50 or above), and can cause severe visual impairments or even blindness if not treated at an early stage. The progression of DR can be categorized into four stages (as per the clinical standards), where the perceptible symptomatic appearances of the disease can only be visualized in the last stages when it becomes nearly impossible to fully recover the vision loss. DR is caused by the blood vessels rupturing due to high blood sugar levels. These leaky vessels produce fluid clots and oxygen deficiency, leading to severe visual impairments. Clinically, DR is classified into two types, i.e., proliferative and nonproliferative Diabetic Retinopathy (NPDR). NPDR is an early DR stage in which retinal lesions such as hard exudates, microaneurysms, hemorrhages, and cotton wool spots appear on the macula. If the disease is left untreated, then abnormal blood vessels from choroid intercept the retina, resulting in choroidal neovascularization. This is the severe stage of DR, dubbed as proliferative DR (PDR), which may result in complete blindness. Apart from this, NPDR is further graded into three stages, i.e., mild, moderate, and severe NPDR, where the severe NPDR is transitioned into PDR due to the lack of proper and timely treatment [2]. Moreover, according to a recent survey, around 333 million diabetic subjects are forecasted to have a high risk of retinal abnormalities (especially DR), thus requiring proper retinal examination by 2025 [3]. At present, 387 million people are diagnosed with diabetes mellitus (DM) worldwide, with an estimated increase in count to 592 million people by 2035 [4]. Among these 387 million people, 93 million people are with positive DR [5]. The alarming figure of 28 million people out of those 93 million people have reached the vision-threatening stage. Patient vision impairment/eyesight loss count can be effectively reduced with early/timely detection of DR with a certainty of accuracy. Overall, 5–8% of people with early-stage DR can be treated with laser technology. According to a survey conducted by WHO, improper examination or late diagnosis might leads to permanent blindness in diabetic patients. However, the progression of the disease can be reduced if diagnosed at an early stage. The intelligent self-learning and decision-making system designed to process medical images for the detection and classification of DR can be used as a decision support system to detect and stop the progression of disease at an early stage. Autonomous disease detection systems provide an efficient and timely solution with the ease of non-invasive image acquisition. In the proposed algorithm, we have designed deep learning framework to accurately classify the detected fundus image into one of the five stages of DR. The major research contributions covered in the paper are as follows: 1. A custom lightweight CNN is proposed to handle a complex multi-class problem. 2. A new pre-processing pipeline including different color spaces for fundus images is proposed to compliment CNN architecture, which has lowered the burden from CNN architecture. 3. A new ensemble approach is presented to handle inter-class similarities in a robust manner. 4. Deep features are complimented with a random forest classifier to reduce trainable parameters. This research article is organized as follows. Starting from Section 1, i.e., a brief introduction followed by Section 2, comprised of literature review highlighting the research gaps in this area. Section 3 explains the proposed methodology in detail, i.e., all three proposed frameworks along with the parameter details, and classifier selection. Results, comparison and dataset details are elaborated in Section 4 followed by the conclusion, i.e., Section 5. Lastly, All of the citations are referred.